

# PORTABLE DATA TRANSFER AND MASS STORAGE DEVICE FOR REMOVABLE MEMORY MODULES

## CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a continuation of Application No. 09/149,448, filed September 9, 1998, now pending, the entire content of which is hereby incorporated by reference in this application.

## FIELD OF THE INVENTION

This invention relates generally to data transfer and storage devices. More particularly, the invention relates to a hand-held, battery-powered, portable device for transferring data between, for example, a flash memory module used in conjunction with a digital camera or audio device and a mass storage device.

## BACKGROUND AND SUMMARY OF THE INVENTION

Over recent years, digital cameras have been rapidly growing in worldwide popularity. Such cameras provide many advantages over the conventional film camera. For example, digital cameras do not require the time and financial expenditures of conventional cameras in terms of film development. Digital cameras are designed to be used in conjunction with a wide range of sophisticated computer graphics processing packages not available for conventional film cameras. Display devices associated with certain digital cameras advantageously

provide the photographer with an enhanced ability to frame desired images and to review pictures just taken.

Digital cameras, however, are not without their disadvantages. Conventional high resolution digital cameras are currently very costly and employ expensive memory media which are capable of only capturing a relatively limited number of pictures. Such cameras may utilize a flash memory module having a storage capacity of, for example, 2 to 32 megabytes. These memory modules become increasingly more expensive as the storage capacity increases.

A high resolution digital camera with a conventional flash memory module may only have a storage capacity to permit a photographer to take a very limited number of pictures such as, for example, a half dozen or even fewer pictures. The vacationing photographer may choose to undertake a major expense to be assured of having enough memory modules to record memorable events from a two week vacation.

In accordance with an exemplary embodiment of the present invention, this digital camera shortcoming is overcome by a hand-held, battery-powered portable device for transferring data between a flash memory module and a mass storage device. The mass storage device may be able to store, for example, the contents of the equivalent of hundreds of flash memory modules.

In accordance with one exemplary embodiment of the present invention, the contents of a flash memory module inserted into an insertion memory port in the portable hand-held device is downloaded under operator control to a mass storage

device in the form of a fixed or removable hard disk drive. Thereafter, the memory module is reinitialized so that it may be immediately reused in its associated camera.

The above-described features and other advantages of the present invention will become apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective illustration of an exemplary embodiment of the present invention showing a hand-held housing and an exemplary component layout.

Figure 2 is an exemplary block diagram of an exemplary implementation of the data transfer and storage system shown in Figure 1.

Figure 3 is a block diagram depicting the system controller logic shown in Figure 2.

Figure 4 is a flowchart of exemplary firmware depicting the portable storage device main system operation.

Figures 5A -5D are flowcharts delineating the sequence of processing for copy, erase, and computer interface command operations.

## DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Figure 1 is a schematic, perspective illustration of an exemplary embodiment of the data transfer and storage device in accordance with the present invention. The battery-powered device for transferring data includes a housing 10, which preferably is of a size which can be comfortably held in a user's palm and which is lightweight and readily portable.

As shown in the right hand portion of Figure 1, the data transfer device includes a flash memory input port 22. In the exemplary embodiment, port 22 is utilized to receive and electrically couple a memory module removed from a digital camera (or other device) to the mass storage device 20 under microprocessor control, as will be explained further in conjunction with Figures 2-5. In the presently preferred embodiment, flash memory input port 22 is designed to receive the commercially available Toshiba SmartMedia flash memory module standard. The SmartMedia memory standard is utilized in various digital cameras and may be directly interfaced with a PC's disk drive, for example, via the commercially available FlashPath product. The SmartMedia module includes a flash memory chip, and processing circuitry in the form of a state control machine which controls reading and writing operations to an 8-bit bus. It should be understood that the present invention is not limited to any particular memory media, but may be utilized in conjunction with a variety of memory media where bulk data transfer is desirable. Although the memory module in the presently preferred embodiment contains image data captured from a digital camera, it should be understood that it alternatively may store any type of computer data including audio data used, for example, to reproduce music.

The data transfer and storage device of the presently preferred exemplary embodiment additionally includes an optional second memory input port 24, which is preferably designed to receive a storage media of a different standard than the memory media received in input port 22. By way of example only, the second memory input port 24 is designed to receive the CompactFlash or MMC media sold by SanDisk Corporation and/or the Sony Memory Stick. One or more of the memory media inserted into input ports 22 and 24 may include a microcontroller for performing more sophisticated processing operations as, for example, is done in the CompactFlash product.

Thus, the data transfer and storage device of the presently preferred embodiment is designed to accept more than a single standard flash memory card, and includes multiple slots (e.g., two or more) to support more than one standard. Because input ports 22 and 24 accept memory media of different standards, the media are coupled to mass storage device 20 via different interface and/or control logic circuitry as will be appreciated by those skilled in the art.

User interface keys 16, 18 are utilized by a user to initiate a download of information from the memory media to the mass storage device 20. At least one control key is provided for initiating the download operation. Another user interface key is used to reformat the memory module in accordance with its requirements for reuse in, for example, a digital camera for taking further photographs. The memory module is reformatted to reinitialize the memory module to place it in its initial default state where no data is stored. A "reformat" control key/button may be utilized to, for example, initiate the erasure of data stored on the media. By way of example, the erasure operation may delete all the

files on the media, or in more sophisticated embodiments delete certain directories or subdirectories.

In an alternative embodiment of the present invention, the user interface keys 16, 18 comprise a portion of a miniaturized keyboard, which may, for example, be utilized to select particular files and directories to copy to the mass storage device 20, which may (prior to downloading) be displayed on, for example, an LCD display (not shown). Graphical images may be displayed on the LCD display so that the user may preview a particular video image to decide whether it should be saved for long term storage. Such a capability advantageously provides the user with added selectivity and flexibility as to what image data is most desirable to maintain in mass storage device 20.

As opposed to using an LCD display, the user display may include, for example, LED display indicators 12 and 14. Display indicators 12 and 14 may display a wide range of status indications such as, for example, indicating that the flash memory copying operation is complete, and that the power is on. Additional display indicators may show the status of other operations such as, for example, a download operation being in progress.

Figure 1 also depicts printed circuit board 28, which supports the electronic components schematically represented in Figure 1 and which is shown in further detail in Figure 2. These components are preferably powered by rechargeable batteries stored in battery compartment 26 and/or an AC adapter may be used.

Data is extracted from the Figure 1 data transfer device through serial/parallel ports 30. Ports 30 are utilized, for example, after flash memory module data has been downloaded from multiple modules to mass storage device 20. The serial/parallel ports 30 permit downloading information from the Figure 1 portable data repository to the user's personal computer at a convenient future time.

Ports 30 are intended to encompass a wide range of I/O ports including, for example, a Universal Serial Bus (USB), a parallel port, and a high speed serial port, such as a Fire Wire port or any desired subset of these or other known ports. The ports 30 may be designed to receive modules plugged into sockets for operating one of the desired ports.

Mass storage device 20 is preferably a commercially available hard drive. By way of example, such a hard drive may be a 2.5 inch hard drive or other appropriately sized hard drive commercially available from various vendors. The mass storage device 20 preferably includes at least one gigabyte of storage. The mass storage device 20 may, in accordance with one embodiment of the present invention, be fixed internally, or in another embodiment, removable from housing 10. In accordance with yet another embodiment of the present invention, the mass storage device 20 may be a battery backed SRAM. By way of example only, another option for mass storage device 30 is a high capacity flash memory module.

Figure 2 is a block diagram showing the electronic interconnection between components of an exemplary embodiment of the data transfer and storage device of the present invention. As also depicted in Figure 1, Figure 2 includes a flash

memory socket 22 and a second memory socket 24 which may be, by way of example only, respectively configured to receive Toshiba's commercially available SmartMedia, SanDisk's Compact Flash or MMC media, or the Sony Memory Stick. The SmartMedia is, in the exemplary embodiment, directly connected to system bus 33. System controller logic 54 includes the logic circuitry for transferring data from, for example, the Smart Media and Compact Flash memory media onto the system bus 33 for transfer to mass storage device 20 as will be explained below in conjunction with the description of Figure 3.

Figure 3 is an exemplary implementation of the Figure 2 system controller logic 54 coupled to memory media receiving sockets 24, 25 and 26. In accordance with an exemplary embodiment, sockets 24 and 26 are conventional PCMCIA ports which are electrically and mechanically compatible with the memory media coupled thereto. Thus, the Compact Flash socket 24 is a PCMCIA socket which is mechanically and electrically compatible with a Compact Flash media. If storage device 20 is implemented as a hard drive, a conventional hard drive ATA/IDE socket 25 is used to couple mass storage device 20 to the system controller logic 54. If mass storage device 20 is selected to be a removable hard drive, then a PCMCIA socket 26 may be utilized.

The system controller logic 54 manages the various memory devices to which it is connected under processor 31 control via system bus 33. The system controller logic 54 includes a SmartMedia address register 64 which is coupled to the flash memory/Smart Media socket 22 and which stores the Smart Media starting address to be accessed. Data may then be written to or read from the



identified SmartMedia flash memory starting address. Similarly, RAM address registers 66 define desired starting addresses in RAM 32.

DMA controller 68 manages data flow between the various memory devices and may be implemented by a conventional DMA controller having a byte transfer counter and control registers. Through DMA controller 68, data may be moved from, for example, SmartMedia to RAM 32. Under such circumstances, processor 31 loads the appropriate addresses into Smart Media address register 64 and RAM address register 66. The byte transfer counter in DMA controller 68 is then loaded by processor 31 with the number of bytes to be transferred and a DMA controller 68 control register is loaded with information specifying the appropriate operation.

A conventional PCMCIA controller 60 may be utilized to control data exchange operations between the media in PCMCIA sockets 24 and 26 and devices coupled to system bus 33. Controller 60 includes an address decoder (not shown) that is coupled to the system bus 33. Controller 60 also includes configuration registers (not shown) which identify configuration information such as the number of memory media or other devices to which it is connected and the device which is currently communicating with processor 31. Controller 60 also includes a storage device for buffering data, and internal buses for interconnecting controller components. A conventional ATA/IDE controller 62 interfaces hard drive 20 with the system bus 33 and the devices connected thereto. As described above in conjunction with controller 60, ATA/IDE controller 62 includes an address decoder, configuration registers, a memory and internal bus for interfacing with hard drive 20.

Turning back to Figure 2, data transfers are preferably initiated via a user keyboard, control keys, or buttons 36 under the control of processor 31. In one embodiment of the present invention, a miniature keyboard is utilized by a user to associate notes with an identified image, change the name of files, or to selectively create directories identifying where the user desires to move data.

As set forth in conjunction with the description of Figure 1, the present invention contemplates a wide range of possible user graphic interfaces. For example, LED's may be utilized to indicate a downloading or other status condition. Alternatively (or additionally, if desired), an LCD display may be utilized for visually depicting, for example, a file name or subdirectory to permit the user to selectively delete undesirable pictures, which also may be displayed for the user to review.

Processor 31 may be any of a wide range of processors but preferably is a RISC-based, for example, 8 bit processor, such as the Atmel 8513. Processor 31, like each of the other components embodied in the data transfer and storage device, is selected to provide optimally low power consumption. Thus, while a variety of different processors may be selected, processor 31 is preferably a high speed processor having extremely low power consumption. The processor's operating system is resident in ROM 34.

The data transfer and storage device shown in Figure 2 also includes RAM 32. RAM 32 stores operating system (and other processing) variables and buffers data being transferred between, for example, memory modules inserted into ports 22 and 24 and mass storage device 20.

The serial/parallel ports 30 represented in Figure 1 are shown in Figure 2 as USB interface 40, Fire Wire interface 42, and parallel port interface 44. These interfaces are utilized for transferring data from mass storage device 20 to, for example, a user's PC or notebook computer. For users having older computers which do not include a USB or Fire Wire interface, parallel port interface 44 may be utilized for downloading data to the user's computer. For newer computers, high speed data transfer may be accomplished via the USB or Fire Wire interfaces 40 or 42, respectively. The output interface ports shown in Figure 2 are provided by way of example to indicate that a variety of interfaces are contemplated for interfacing with a wide range of user's computers.

The portable device shown in Figure 2 typically operates under battery power such as, for example, by rechargeable AA batteries 50. Power supply 48, in addition to being powered by batteries 50, may also receive external power to permit a user upon arriving home to save battery power by using household power during uploading information to his or her computer. The external power source also permits batteries 50 to be recharged if rechargeable batteries are being used.

Mass storage 20 is preferably a hard drive as set forth in conjunction with Figure 1. It is also contemplated that mass storage 20 may be a removable hard drive, a SRAM, or a large storage capacity, high density flash memory or other mass memory media which is commercially available today or becomes commercially available in the future. Mass storage device is coupled to control logic 54 via an ATA/IDE bus or a PCMCIA.

Figure 4 is a firmware flowchart showing an exemplary set of processing operations that the present preferred embodiment sequences through. After power is turned on (100), processor 31 executes a power-on self test routine whereby the integrity of the device is initially confirmed. The device internal logic is exercised and checked to a limited extent before operating data transfer device. Initially, the integrity of processor 31 and its associated firmware is checked. Next, the user interface functions, the I/O ports, and the mass storage device are checked (102). The power-on self tests include executing diagnostic routines to ensure, for example, that RAM 32 is operational.

Thereafter, a command interpreter loop is entered (104). The system monitors all associated input/output devices for activity to determine the next operation to initiate (104). As represented schematically at block 106, an operation is initiated by a user, for example, actuating a copy or erase button. Alternatively, activity may be detected by processor 31 via the Figure 2 USB, Fire Wire, or parallel ports 40, 42, and 44 (110). If activity is detected via the host computer system input, then processor 31 must interpret the host command.

At block 108 a check is made to determine whether the detected operational command is a copy memory module command. If so, "copy" operation processing is initiated, whereby data from a memory module is downloaded to mass storage 20 as set forth in the flowchart of Figure 5A. Initially, the integrity of the data in the memory module is verified to determine that the memory media is a valid module (120). Thus, if the data stored in the memory module does not conform with the appropriate standard format, a "copy" operation will not be performed and an indication will be displayed to the user that the memory module is bad.

Such an indication may be displayed, for example, via a status indicating LED or on an LCD display (122).

If the data integrity of the module is good, then subdirectories are created on the mass storage unit (124). Thus, in the process of making such data transfers, processor 31 creates appropriate subdirectories which, for example, may be sequentially numbered for each module that is inserted into, for example, socket 22. Each flash memory module may include its own subdirectory having all the contents of that module resident therein. The contents of the module is then copied into the created subdirectory. After the subdirectory has been created at block 126, the directory structure from the module is copied to the mass storage device (126). Thereafter, the files from the memory module are copied to the mass storage device 20 into the directory structure that had been created (128).

After the data has been copied, the integrity of the data that has been copied is verified to, for example, determine whether data has been loaded onto a defective portion of the hard drive, or whether there has been a power failure or a component failure (130). If the data cannot be verified, then an indication that the copying operation failed is conveyed to the user via a status LED or via an LCD display (132). If desired, an indication of the nature of the error may be displayed on an LCD display. If the integrity of the data is verified, then the user receives an indication that the copying operation has been successfully completed via a status LED or LCD (134) and the routine branches back to the command interpreter block 104 to await further activity.

If a copy memory module operation was not initiated then, as shown in Figure 4, a check is made to determine whether an “erase memory” command has been initiated (140). If so, the routine branches to the flowchart shown in Figure 5B, which delineates erase operation processing. Erase operation processing is utilized, for example, to prepare a flash memory module for reuse so that further pictures can be taken with the user's digital camera. Initially, a check is made to verify the data integrity of the memory module (150). This check ensures that the module has, for example, the proper data fields or supported density or supported voltage before any operation is performed thereon. If the memory module is determined to be bad, then the user receives a “bad memory media” indication, either via a status LED or via an LCD display (152).

If the module has been verified as being a valid module, then the desired files are deleted from the module (154). If the files cannot be deleted, then information is conveyed to the user that the erase operation has failed via a status LED or an LCD display (156). After the files have been deleted, memory media subdirectories are deleted (158). If the subdirectories cannot be deleted, then an indication is conveyed to the user that the erase operation failed via status LED or a LCD display (160). After subdirectories have been deleted, an indication is conveyed to the user that the erasure operation was successful via a status LED or LCD display (162) and the routine branches back to the Figure 4 command interpreter.

If an “erase memory module” operation has not been initiated, then a check is made at block 170 to determine whether a computer interface command was

initiated. If so, the routine branches to the Figure 5C flowchart depicting computer interface command processing.

Computer interface processing typically occurs after the user, for example, has completed a photography session and has interconnected the portable data storage and transfer device to his or her PC. During such operations a user may download pictures stored in the mass storage device to the PC or alternatively, upload, for example, pictures stored in the PC to the portable storage device's mass media.

Initially, a check is made at block 200 to determine whether an I/O request has been received from a user's host PC and, if so, what kind of request has been initiated. As indicated at block 202, a check is made as to whether the requested activity is to upload or download data from or to mass storage device 20 to, for example, upload or download pictures (202). By uploading pictures from a user's PC, the portable data transfer and storage device thereafter may be utilized to hand-carry highly desirable pictures from one user's PC to another user's PC. Depending upon the desired direction of data transfer, data is either read from or written to the host or the mass storage device 20 (204). As indicated in Figure 5D, a status report is then sent to the host and the routine branches back to Figure 4 and its command interpreter block 104. During the data transfer process from or to the mass storage, the user would have the ability to delete files, rename files, and a wide range of other conventional file processing operations. Such host/mass storage data exchanges operate under the control of software resident in the user's PC.

As indicated at block 206, a check is also made to determine whether data exchanges are to take place between the memory module and the host computer (206). In this fashion, reading to or writing from the host to the memory module is controlled (208). Similar to exchanges between the host PC and mass storage, a wide range of data transfer operations may be controlled. After the host to memory module data exchange, a status report is sent to the host (210) and the routine branches back to the Figure 4 command interpreter 104.

If the processing of block 200 reveals that an I/O request was received from the host, a check is also made to determine if the request was a diagnostics command (212). Such diagnostics may appropriately be initiated either during the device manufacturing phase or for user diagnostics. Initially, a check is made as to whether to initialize mass storage 20 (214). If the check at 214 indicates that mass storage is to be initialized to, for example, recover from a failure, the storage device 20 is reformatted (216), a status report is transmitted to the host (Figure 5D at 210), and the routine branches back to the Figure 4 command interpreter (104).

If the check at block 214 indicates that the mass storage 20 is not to be initialized, then a check is made to determine whether self test processing is to be initiated (218). If self tests are to be initiated, then self test processing begins (220). The self tests performed at block 220 are more comprehensive than the power-on self tests previously referenced in that they output diagnostic information useful to service personnel for correcting a problem relating to processor 31 and its associated firmware, the user interface devices, the I/O ports and the mass storage device. Upon completion of these tests, the host processor is



sent a status report (210) and the routine branches to the Figure 4 command interpreter block 104.

If no self test command was received, a check is made to determine whether the memory media should be tested (222). If so, the integrity of data from the memory module is checked to respond for example, to a user complaint that the memory media can not be read. Service personnel can then determine that, for example, a particular data field has been corrupted requiring reformatting of the module. If no memory module testing has been initiated, the routine branches back to the command interpreter at block 104.

If no computer interface command has been initiated as determined at block 170, a check is made at 172 (Figure 4) to determine if the user has depressed a power off key or alternatively has let the data transfer device sit idle for more than a predetermined idle time. If so, the device powers down (174). If not, the routine branches back to command interpreter block 104 to continue checking for command related activity.

The present invention may be utilized in a wide range of applications in addition to being used by amateur photographers. For example, the present invention may be used in conjunction with a team of professional photographers covering an event for a newspaper or magazine. Individual photographers having digital cameras may, for example, meet at a central location and transfer flash memory modules to a colleague having the present data transfer and storage device for storage of all the data. Such accumulated data may thereafter be downloaded to the newspaper's or magazine's central office computer.

It will be understood by those skilled in the art that the foregoing description is in the terms of a preferred embodiment of the present invention, wherein various changes and modifications may be made without departing from the spirit and scope of the invention as set forth in the appended claims.